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NAVAL RESEARCH LABORATORY

E.O. Hulburt **Center for Space Research**

Monthly Progress Report
for the
SOLAR-B Mission
Extreme Ultraviolet (EUV) Imaging Spectrometer (EIS)
Instrument Components

Phase C/D Cumulative Project Period Through 31 July 2001

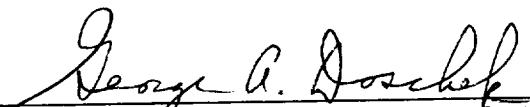
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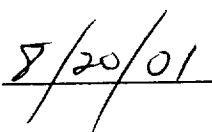
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1.0 INTRODUCTION

This Monthly Progress Report covers the reporting period through July 2001, Phase C/D, Detailed Design and Development Through Launch Plus Thirty Days, for selected components and subsystems of the Extreme ultraviolet Imaging Spectrometer (EIS) instrument, hereafter referred to as EIS Instrument Components. This document contains the program status through the reporting period and forecasts the status for the upcoming reporting period. This document has been developed in accordance with Data Requirements Description 887MA-002.

2.0 PHASE B SCHEDULE

Appendix A presents the EIS Instrument Components program schedule, reflecting progress through July 31, 2001. The program schedule reflects activities through Phases C/D and launch. The program schedule reflects the one-year launch delay.

3.0 SUMMARY OF WORK ACCOMPLISHED DURING REPORTING PERIOD

During the month of July, the following work was accomplished on the EIS Instrument Components.

3.1 Science Objectives

The working group on science data products (Mariska, Zarro, and Hansteen) developed a first pass at a brief statement of the science data products that EIS expects to produce on a routine basis. During the reporting period, work continued on putting together the three month EIS observing plan.

3.2 Design Principles

3.2.1 Hardware Design

Various aspects of the EIS hardware design were worked during the reporting period. A summary of these activities includes:

- Developed the test plan for DM FFA acoustic tests. This test was conducted on the EM CLM and one DM FFA quadrant (under partial vacuum). Also tested two small filters from Skylab scrap at 1 atm. (enclosed in small boxes);
- The DM MIR assembly began thermal vacuum testing. At the close of the reporting period, the assembly had completed both the hot soak, hot start, cold soak and cold start and was proceeding to temperature cycling under vacuum;
- Conducted three days of vibration tests on the EM filter under partial vacuum in the CLM. Eventually the filter failed at very high vibration levels. This is thought to be due to a severe overtest at high frequencies. A faulty control accelerometer was found and led to extremely high input levels at frequencies above 500hz. Subsequently, the fundamental of the CLM spider was found to be

at 565hz. A full analysis of the failure is in progress. Much was learned about how filters break. Vibration testing will resume after the failure is fully understood. The test specification may be revised to limit metal fatigue and to properly notch for the CLM spider fundamental frequency. The failure is documented in Failure Report NRL/SLB-EIS/FR/151;

- Received test results from the ASTM E 1559 outgassing/deposition kinetics testing conducted on two samples of CFRP panels provided by BU for test. A copy of this report⁶ is provided as Appendix B;
- Requested and received a sample of the solid CFRP material from BU for outgas testing to be performed similar to the testing conducted on the samples reported in Appendix B;
- Bonded the slit/slots to their frames for the DM SLA. The slit microscope adapter plate was manufactured so the slits can be measured and evaluated;
- Discussed purge harness tubing requirements with Japan and the University of Birmingham (BU);
- Requested BU to construct a thermal model of the CLM environment. Provided filter information in support of the model. A double layer sheet metal thermal shield was suggested for the front door of the CLM as a result of the thermal modeling;
- Designed test cube for Entran EPV Sensors & sent to shop for fabrication;
- Progressed design of PZT calibration fixture;
- Discussed position and design of alignment cubes with BU;
- Determined that the teflon material from McMaster-Carr can be considered "Virgin" material for contamination purposes;
- Received the EM SEF filters from Luxel. Began designs for acoustic and vibration test fixtures for these;
- Received grating shipping containers from shop. Initiated the cleaning process;
- Held a meeting at GSFC to discuss the ML coating program progress and plans;
- Prepared an EIS Technical Document (NRL/SLB-EIS/PS/259.01) describing the handling of the Al filters and their installation in the CLM;
- The engineering team was very active in developing the engineering documentation required for participated in the EIS Critical Design Review in Huntsville, Alabama;
- The engineering team supported MSFC in establishing a disposition baseline of the Review Item Discrepancies (RID's) recorded during the EIS CDR.

3.2.2 Systems Engineering

Continued participation in weekly teleconference calls with MSSL and the University of Birmingham, via a three-way calling scheme, to discuss EIS systems engineering issues. Emphasis has been placed on status of the MTM/TTM build and test program currently underway in the UK. During the reporting period, NRL did bring the Rutherford Appleton Laboratory (RAL) onto the call to discuss EIS level contamination issues. In the near future, RAL will become part of the weekly calls on a regular basis.

3.3 Documentation

3.3.1 Contract Documents

During the reporting period the following documents were submitted:

- EIS Instruments Components Monthly Progress Report submitted in accordance with 887MA-002;
- EIS Instrument Components Financial Management Report (533M) submitted in accordance with DRD 887MA-003;

3.4 Meetings

The EIS Instrument Components team participated and presented at the EIS Critical Design Review, held in Huntsville, AL 11 and 12 July.

4.0 SUMMARY OF WORK TO BE ACCOMPLISHED DURING UPCOMING REPORTING PERIOD

During the next month, August 2001, the following work is scheduled to be conducted on the EIS Instrument Components.

4.1 Science Objectives

Continue working in the Science Working Groups.

4.2 Design Principles

Work will continue on further defining the Development Model EIS optical and mechanism designs. The DM SLA will be subjected to qualification level vibration, the DM SEF will undergo acoustic testing and the DM MIR will complete thermal vacuum testing. Weekly systems engineering conference calls will continue with the UK EIS teams. The engineering team will support the EIS CDR.

4.3 Documentation

During the next reporting period, the following documentation is to be submitted:

- EIS Instrument Components Monthly Progress Report per 887MA-002;
- EIS Instrument Components Financial Management Report (533M) per 887MA-003.

4.4 Meetings

There are no official meetings scheduled for August 2001.

5.0 TECHNICAL PROBLEMS AND IMPACT TO SCIENCE OBJECTIVES

At this time there are no significant problems identified that would impact the EIS science objectives.

6.0 SCIENCE INSTRUMENT INTERFACES

Table 1 presents the updated mass estimates for the complete EIS instrument.

7.0 CURRENT AREAS OF CONCERN

The following areas are of concern at this time to the EIS development program:

- The necessity to implement adequate contamination control in Japan upon delivery of the EIS flight hardware to prevent contaminating the EIS optics.
- The NRL engineering team has completed a preliminary contamination model for the FFA and front aperture of the EIS instrument. These results show that there are serious concerns with contamination impacts from the spacecraft. NRL is working with MSSL to inform the J-side of the concerns and recommendations.

8.0 COST SUMMARY

Cost data has been removed from the Monthly Report and included as part of the EIS Instrument Components Financial Management Report (533M).

9.0 RISK ASSESSMENT

Table 2 contains a listing of the top ten risks associated with the NRL EIS Instrument Components program. The purpose of this list is to identify and track the top ten risks. Each risk is assigned a probability figure, which can be described qualitatively as:

<i>Term</i>	<i>Notation</i>
Impossible	0
Very unlikely	1
Unlikely	2
Moderately Unlikely	4
Moderately Probable	6
Probable	8
Very Probable	9
Certain	10
Unknown	99

Table 1. EIS Instrument Estimated Mass Figures

ITEM	ACRONYM	MASS (kg)	TOTAL (kg)	COMMENTS
NRL Instrument Components				
Primary Mirror	MIR	3.37		Per NRL ICD
Grating	GRA	1.52		Per NRL ICD
Filters	FFA & SEF	0.19		Per NRL ICD
Slit/Slot/Shutter Assembly	SLA	0.73		Per NRL ICD
	TOTAL		5.81	
EIS Instrument				
NRL Instrument Components		5.81		
Structure	STR	28.00		Composite structure
Launch Lock	LOK	1.00		Typical for LASCO type
Mirror Mount		0		Included in Primary Mirror
Scan Mechanism		0		Included in Primary Mirror
Grating Mount		0		Included in Grating
Grating Mechanism		0		Included in Grating
Focal Plane Assembly	FPA	0.9		Estimate
Shielding		0.60		Estimate
Readout Electronics	ROE	2.50		Estimate
Radiator		4.00		Estimate
Comtam Monitors	QCM	0.36		
Sensors & Heaters		0.20		Estimate
Multilayer Insulation	MLI	3.00		15 layer blankets with alternating mesh
Instrument Control Unit	ICU	6.55		Estimate
Harness	HAR	4.00		Scaled from LASCO
Clamshell	CLM	2.50		
Mech/Heater Control	MHC	3.0		Estimate
Purge Harness	PUR	2.0		Estimate
Vacuum Harness	VAC	1.0		Estimate
Unaccounted mass held by UK side		2.01		
	Total		67.43	

Table 2. Top Ten Risks Associated with the NRL EIS Instrument Components

Priority	Probability	Event	Effect	Management	Notes
1	2	Failure of the flight Grating optic manufacturer (Zeiss) to meet the procurement specifications; manufacturing defects.	Depending on degree of defects, optics may be found to produce loss of throughput, may be unusable for flight.	NRL has placed three Grating optics on order in accordance with the Grating Procurement Specification. In addition, NRL has placed on order, with Zeiss, three optical blanks as back-up optics to minimize the procurement time.	Zeiss has proven capabilities to meet the procurement specifications for making the Grating optics.
2	4	Failure of the flight Mirror optic manufacturer (Tinsley) to meet the delivery schedule.	Late delivery will impact delivery of the flight MIR assembly to the UK for EIS Instrument integration.	NRL has implemented schedule contingency into the flight MIR development program. NRL is currently looking into a back-up MIR optics vendor.	
3	2	MIR optics inadequately figured or polished.	Poor focusing properties leading to loss of spatial and spectral resolution. Possible need for rework.	NRL has calculated an optics error budget. In addition, three flight MIR optics are being produced.	
4	2	Multilayer coating fails to provide adequate reflectivity or other properties.	Loss of optical throughput	<ol style="list-style-type: none"> 1. There is currently a test program underway where a series of wafer samples are undergoing the multi layer coating process and then evaluated for performance; 2. Three optics for both the MIR and GRA are being procured to allow for errors.. 	
5	2	Subassembly failure during environmental testing	Delay in delivery while rework and retest are underway.	The program schedule currently contains six weeks of schedule contingency for the test program.	
6	4	Excessive lead times on flight components for the flight Mechanism Driver Electronics printed circuit boards.	Delay in delivery of the MDE PWA's to MSSL for integration into the Mechanism and Heater Controller.	<ol style="list-style-type: none"> 1. Evaluate all potential, qualified component vendors; 2. Identify compatible replacement part numbers; 3. Allow adequate schedule contingency 	NRL received official confirmation for delivery of the flight MDE PWA's in June 2001. Currently there are no components with excessive leadtimes, however, final parts procurement is not complete.
7	2	Failure of a lot of MDE flight components during additional component screening	Delay in delivery of the MDE PWA's to MSSL for integration into the Mechanism and Heater Controller.	<ol style="list-style-type: none"> 1. Identify high risk components; 2. Identify compatible replacement part numbers 3. Allow sufficient lead time in the schedule for a re-buy if necessary. 	

Table 2. Top Ten Risks Associated with the NRL EIS Instrument Components (Continued)

Priority	Probability	Event	Effect	Management	Notes
8	1	Failure of an NRL delivered component to integrate properly into the EIS Instrument	Delay in delivery of the EIS Instrument to the J-side during rework and retest.	<ol style="list-style-type: none"> 1. NRL has provided mass models of the GRA, SLA and MIR confirming the subassembly footprints for inclusion into the EIS MTM/TTM model; 2. NRL has integrated the FFA into the University of Birmingham provided EM Clamshell assembly; 3. NRL has successfully integrated the breadboard MDE Analog and Digital PWA's to the MSSL provided MHC EM power subsystem. 	
9	4	Contamination of EIS Instrument Components optics during handling, test or storage while still at NRL.	Loss of optical throughput; possible catastrophic failure of optical component.	<ol style="list-style-type: none"> 1. Implement witness sample monitoring to track flight optics; 2. Spare flight optics have been procured; 3. Implement adequate contamination monitoring and controls 	
10	8	Contamination of the EIS Instrument during integration, test and early orbit.	Loss of total instrument throughput.	NRL is working with the UK contamination team to ensure that adequate controls and design modification are incorporated.	Under the current EIS Instrument design, the preliminary contamination model performed on the FFA and front aperture of the instrument shows a high probability of contamination from the spacecraft.

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Appendix A. EIS Instrument Components Baselined Master Schedule

WBS Code	Description	Rem Dur	Early Start	Early Finish	2000	2001	2002	2003	2004	2005
0.1	Solar-B Master Schedule Major Milestones	1053	08/20/01	09/01/05						
1.1	Protomodel Test in Japan	20	08/20/01	09/14/01						
1.2	MTM/TTM Test in Japan	160	12/03/01	07/12/01						
1.3	EIS Instrument Flight Hardware Due at ISAS	0	12/02/03	07/20/05						
1.4	S/C Integration and Test	427	12/02/03	07/20/05						
1.5	Launch	0	09/01/05	10/31/01						
0.2	Solar-B EIS Instrument Components	1110	02/01/99	10/29/99 A						
A	Phase A: Concept Study	0	02/01/99 A	10/29/99 A						
B	Phase B: Definition and Preliminary Design	0	11/01/99 A	12/31/00 A						
C	Phase C: Detailed Design	0	01/01/01 A	07/11/01 A						
D	Phase D: Development Through Launch Plus 30 D	1085	07/12/01	09/30/01						
E	Phase E: Mission Operations and Data Analysis	21	10/03/05	10/31/05						
1.0	Management, Science & Co-Investigators	1110	02/01/99 A	10/31/05						
1.1	Project Management	1006	09/01/99 A	08/01/05						
1.1.1	Meetings - Programmatic	917	09/01/99	08/01/01						
1.1.1.1	Requirements Review	0	09/01/99 A	09/02/99 A						
1.1.1.2	Concept Review	0	10/28/99 A	10/29/99 A						
1.1.1.3	Preliminary Design Review	0	05/11/00	05/11/00						
1.1.1.4	EIS Instrument UK Preliminary Design Review	0	07/06/00 A	07/07/00 A						
1.1.1.5	Confirmation Review	0	11/30/00 A							
1.1.1.6	Critical Design Review	0	07/11/01							
1.1.1.7	Pre-Environmental Review	0	01/24/02							
1.1.1.8	Pre-Ship/Acceptance Review	0	08/01/02							
1.1.1.9	Mission Readiness Review	0	08/01/05							
1.1.2	Meetings - Scientific	1	11/15/99	09/21/01						
1.1.2.1	EIS Science Meeting - NRL	0	11/15/99 A	11/19/99 A						
1.1.2.2	SOLAR-B Science Meeting - ISAS	0	12/09/99 A	12/10/99 A						
1.1.2.3	EIS Science Meeting - MSSL	0	02/09/00 A	02/09/00 A						
1.1.2.4	EIS Science Meeting - MSS	0	05/24/00	05/26/00						
1.1.2.5	EIS Science Meeting - RAL	0	11/15/00 A	11/17/00 A						
1.1.2.6	Solar-B Science meeting - ISAS	0	12/04/00 A	12/06/00 A						
1.1.2.7	EIS Science Meeting - MSSL	0	04/23/01 A	04/24/01 A						
1.1.2.8	Solar-B Science Meeting - Hawa	1	09/21/01	09/21/01						
1.1.3	Meetings - Technical	0	12/11/99 A	02/23/01 A						
1.1.3.1	EIS Engineering Meeting - ISAS	0	12/11/99 A	12/15/99 A						
1.1.3.2	EIS Engineering Meeting - ISAS	0	03/06/00 A	03/08/00 A						
1.1.3.3	EIS Engineering Meeting - ISA	0	06/20/00	06/22/00						
1.1.3.4	EIS Engineering Meeting - Univ. Birmingham	0	10/04/00 A	10/06/00 A						
1.1.3.5	EIS Engineering Meeting - ISAS	0	12/07/00 A	12/09/00 A						
1.1.3.6	Engineering Working Group- Univ. Birmingham	0	02/21/01 A	02/23/01 A						
1.2	Project Planning and Contr	1110	09/01/99	10/31/01						
1.2.1	Documentation	1110	03/01/99 A	10/31/05						
1.2.1.1	Requirements Review Data Package	0	09/28/99 A	09/28/99 A						

WBS Code	Description	Rem Dur	Early Start	Early Finish	2000	2001	2002	2003	2004	2005
1.2.1.2	Monthly Progress Reports (Monthly)	1110	03/01/99 A	10/31/05						
1.2.1.3	Phase A Concept Study Report	0	10/29/99 A							
1.2.1.4	Financial Management Reports (Monthly)	1110	12/15/99 A	10/31/01						
1.2.1.5	Work Breakdown Structure	0	12/01/99 A							
1.2.1.6	Configuration Management Plan	0	12/16/99 A							
1.2.1.7	Project Management Plan	0	01/07/00 A							
1.2.1.8	Risk Management Plan	0	01/17/00 A							
1.2.1.9	Product Assurance Plan	0	01/31/00 A							
1.2.1.10	Verification Plan	0	04/21/00 A							
1.2.1.11	EIS Component Specification	0	04/21/00 A							
1.2.1.12	Preliminary Design Review Data Package	0	04/21/00 A							
1.2.1.13	Interface Control Documents	0	04/21/00 A							
1.2.1.14	Contamination Control Plan - Updated	0	02/27/01 A							
1.2.1.15	System Error Budget	0	04/21/00 A							
1.2.1.16	Critical Design Review Data Package	0	06/20/01 A							
1.2.1.17	Security Plans for Major Applications	0	03/02/01 A							
1.2.1.18	ECP's and Associated Documentation	0	06/20/01 A							
1.2.1.19	Deviation/Waiver Approval Request (A/R)	0	10/08/01							
1.2.1.20	Engineering Drawings and Associated Lis	0	10/08/01							
1.2.1.21	Handling and Transportation Plan	0	06/20/01 A							
1.2.1.22	Data Management Plan	0	06/20/01 A							
1.2.1.23	Acceptance Data Package	0	01/24/02							
1.2.1.24	Verification Test Report	0	08/15/02							
1.3	Procurement Management	130 *	06/01/99 A	01/30/02						
1.3.1	Planning	0	06/01/99 A	05/01/00 A						
1.3.2	Procurement	130	02/11/00 A	01/30/02						
1.4	Configuration Management	285 *	02/01/99 A	09/02/02						
1.4.1	Definition and Planning	0	02/01/99 A	03/15/00 A						
1.4.2	Implementation	0	03/15/00 A	07/11/01 A						
1.4.3	Configuration Control	285	06/01/00 A	09/02/02						
1.5	Science Support	1110 *	02/01/99 A	10/31/05						
1.5.1	Science Definition	0	02/01/99 A	07/11/01 A						
1.5.2	Science Support	1110	07/12/01 A	10/31/05						
1.5.3	Education & Public Outreach	1110	10/01/99 A	10/31/05						
2.0	Flight System	238 *	02/01/99 A	06/27/02						
2.1	Front Filter Assembly	174 *	06/01/99 A	03/29/01						
2.1.1	Development Model (DM) Filter Assembly	19 *	06/01/99 A	08/24/01						
2.1.1.1	Specify filter requirements	0	06/01/99 A	08/02/99 A						
2.1.1.2	Design Filter Frame	0	08/03/99 A	07/03/00 A						
2.1.1.3	Procure DM Filter Frames	0	09/15/00 A	01/12/01 A						
2.1.1.4	Fit Check DM Filter Frames	0	01/15/01 A	01/26/01 A						
2.1.1.5	Procure Commercial Equivalent Filter	0	11/27/00 A	03/23/01 A						
2.1.1.6	Integrate DM Filter Assembly	0	03/26/01 A	06/01/01 A						

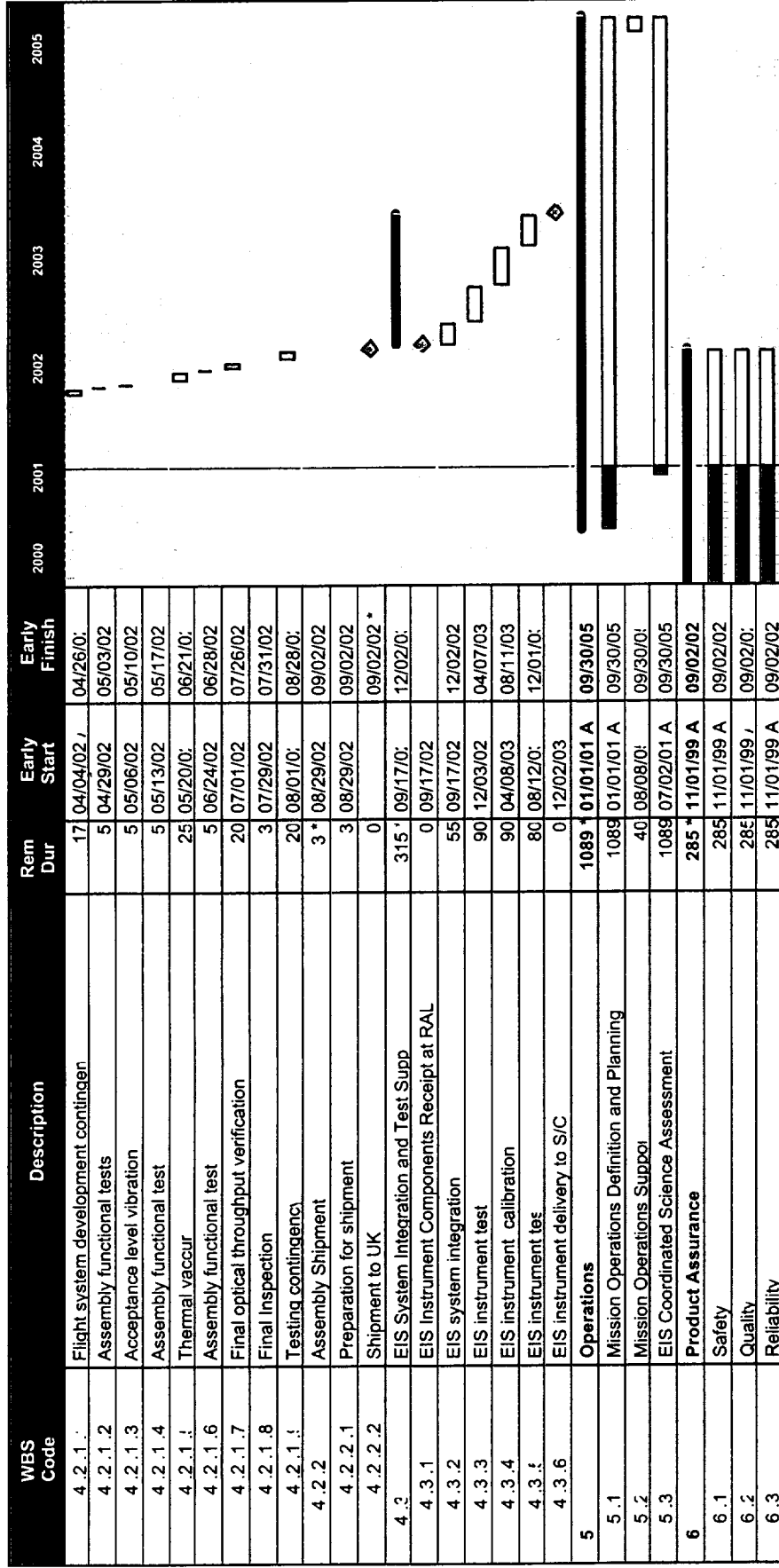
WBS Code	Description	Rem Dur	Early Start	Early Finish	2000	2001	2002	2003	2004	2005
2.1.1.1	Fabricate Mock-up Clamshell Assembly (UI)	0	01/08/01	05/11/01						
2.1.1.9	Vacuum Test EM Clamshell	0	06/04/01 A	06/15/01 A						
2.1.1.10	Integrate FFA Assembly for Test	0	07/23/01 A	07/25/01 A						
2.1.1.11	Fabricate vibration test fixture	0	04/23/01 A	04/27/01 A						
2.1.1.12	Visual Inspection	0	06/26/01	06/26/01						
2.1.1.13	DM Acoustic Test	0	06/27/01 A	06/28/01 A						
2.1.1.14	Visual Inspection/Light Leak Test	0	06/28/01 A	06/29/01 A						
2.1.1.15	DM qualification level vibration test	0	07/25/01 A	07/27/01 A						
2.1.1.16	Visual Inspection	0	07/27/01 A	07/27/01 A						
2.1.1.17	Test/Anomaly Evaluation	19	07/30/01	08/24/01						
2.1.2	Flight Model (FM) Filter	155	08/27/01 A	03/29/02						
2.1.2.1	Update Filter Design	55	08/27/01 A	11/09/01						
2.1.2.2	Procure Flight Filter(s)	40	11/12/01	01/04/02						
2.1.2.3	Evaluate Flight Filter Assembly	20	01/07/02	02/01/02						
2.1.2.4	Integrate to Clamshell Housing	20	02/04/02	03/01/02						
2.1.2.5	Test and Debug	20	03/04/02	03/29/02						
2.2	Mirror Assembly	177	02/01/99 A	04/03/02						
2.2.1	Development Model (DM) Mirror Assembly	35	06/01/99	09/17/00						
2.2.1.1	Define Mirror optical requirements	0	06/01/99 A	11/01/99 A						
2.2.1.2	Preliminary design fine scan mechanism	0	06/01/99 A	11/01/99 A						
2.2.1.3	Fabricate fine scan mechanism	0	11/02/99 A	12/13/99 A						
2.2.1.4	Test/debug fine scan mechanism	0	12/13/99	01/07/00						
2.2.1.5	Preliminary design coarse scan mechanism	0	12/15/99 A	02/15/00 A						
2.2.1.6	Fabricate coarse scan subassembly	0	02/16/00 A	03/07/00 A						
2.2.1.7	Procure commercial mechanism stepper motor/resol	0	04/10/00 A	08/11/00 A						
2.2.1.8	Assembly scanning mechanism	0	08/14/00	01/05/01						
2.2.1.9	Conduct static load testing	0	01/08/01 A	01/19/01 A						
2.2.1.10	Develop bonding technique procedures	0	12/06/99 A	12/17/99 A						
2.2.1.11	Perform bonding test case using mass sim glass	0	12/17/99 A	12/23/99 A						
2.2.1.12	Perform pull/strength test on bond ca	0	12/24/99	12/30/99						
2.2.1.13	Evaluate lightweighting MIR optics	0	12/18/00 A	04/13/01 A						
2.2.1.14	Black Anodize Machine Parts	0	04/02/01 A	04/13/01 A						
2.2.1.15	Integrate mirror assembly	0	04/16/01 A	04/20/01 A						
2.2.1.16	Test and Debug/Functional Test	0	06/11/01	06/15/01						
2.2.1.17	Fabricate vibration test fixture	0	04/23/01 A	04/27/01 A						
2.2.1.18	Vibration Test	0	06/18/01 A	06/20/01 A						
2.2.1.19	Functional Test	0	07/09/01 A	07/10/01 A						
2.2.1.20	Thermal Vacuum Test	10	07/12/01	08/13/01						
2.2.1.21	Functional Test	2	08/14/01	08/15/01						
2.2.1.22	Life Test	20	08/16/01	09/12/01						
2.2.1.23	Functional Test	3	09/13/01	09/17/01						
2.2.2	Flight Model (FM) Mirror	177	04/02/01	04/03/02						
2.2.2.1	Update optical design	10	09/18/01	10/01/01						

WBS Code		Description	Rem Dur	Early Start	Early Finish	2000	2001	2002	2003	2004	2005
2.2.2.2		Update scanning mechanism design	20	07/31/01	08/27/01						
2.2.2.3		Procure Primary Mirror	132	07/23/01 A	01/30/02						
2.2.2.4		Coat primary mirror	15	01/31/02	02/20/02						
2.2.2.5		Characterize primary mirror	10	02/21/02	03/06/02						
2.2.2.6		Procure flight stepper motor/resolver	44	04/02/01 A	09/28/01						
2.2.2.7		Fabricate and assemble scanning mechanism	60	08/28/01	11/19/01						
2.2.2.8		Integrate scanning mechanism - mirror	10	03/07/02	03/20/02						
2.2.2.9		Telescope optical functional testing	10	03/21/02	04/03/02						
2.3		Slit and Shutter Assemb	167	06/01/99	03/20/02						
2.3.1		Slit Assembly Development Model (DM)	67	06/01/99 A	10/31/01						
2.3.1.1		Define slit/slot configuration	0	06/01/99 A	03/20/00 A						
2.3.1.2		Design motor & gearhead assembly	0	07/13/99 A	02/07/00 A						
2.3.1.3		Procure motor & gearhead assembly	0	04/10/00	08/11/00						
2.3.1.4		Fabricate slit/slot inserts	0	01/12/01 A	05/25/01 A						
2.3.1.5		Assemble DM Slit/Slot Assembly	0	12/04/00	07/27/01						
2.3.1.6		Test, debug, functional test	18	07/30/01 A	08/23/01						
2.3.1.7		Fabricate test fixture	0	04/23/01 A	04/27/01 A						
2.3.1.8		Vibration Test	3	08/24/01	08/28/01						
2.3.1.9		Functional Test	2	08/29/02	08/30/02						
2.3.1.10		Thermal Vacuum Test	20	08/31/01	09/27/01						
2.3.1.11		Functional Test	2	09/28/01	10/01/01						
2.3.1.12		Life test	20	10/02/01	10/29/01						
2.3.1.13		Functional Test	2	10/30/02	10/31/02						
2.3.2		Shutter Assembly Development Model (DM)	49	06/01/99 A	10/31/01						
2.3.2.1		Define shutter assembly requirements	0	06/01/99 A	02/07/00 A						
2.3.2.2		Procure shutter components	0	02/07/00 A	04/28/00 A						
2.3.2.3		Fabricate shutter wheel	0	11/01/00	11/22/00						
2.3.2.4		Assemble shutter assembly	0	05/01/00 A	11/27/00 A						
2.3.2.5		Test, debug and functional test	0	11/28/00 A	01/19/01 A						
2.3.2.6		Vibration Test	3	08/24/01	08/28/01						
2.3.2.7		Functional Test	2	08/29/02	08/30/02						
2.3.2.8		Thermal Vacuum Test	20	08/31/01	09/27/01						
2.3.2.9		Functional Test	2	09/28/01	10/01/01						
2.3.2.10		Life Test	20	10/02/01	10/29/01						
2.3.2.11		Functional Test	2	10/30/01	10/31/01						
2.3.3		Flight Model Slit/Shutter Assembly	167	04/02/01	03/20/02						
2.3.3.1		Update Slit assembly design	10	08/29/01	09/11/01						
2.3.3.2		Update Shutter design	10	08/29/01	09/11/01						
2.3.3.3		Procure slit motor & gearhead assemblies	87	04/02/01 A	11/28/01						
2.3.3.4		Procure Shutter component	60	08/01/02	10/23/02						
2.3.3.5		Fabricate slit/slot and shutter wheel	30	09/12/02	10/23/02						
2.3.3.6		Assemble slit/slot assembly	20	11/29/01	12/26/01						
2.3.3.7		Assemble shutter assembly	20	10/24/01	11/20/01						

WBS Code		Description		Rem Dur	Early Start	Early Finish	2000	2001	2002	2003	2004	2005
2.3.3.8		Integrate Shutter/Slit Assemblies		20	12/27/01	01/23/02						
2.3.3.9		Test and Debur		40	01/24/02	03/20/02						
2.4		Spectrometer Filter Assembly		150	06/01/99 A	02/25/02						
2.4.1		Development Model (DM) Filter		15	06/01/99 A	08/20/01						
2.4.1.1		Specify Filter Requirements		0	06/01/99 A	08/02/99 A						
2.4.1.2		Develop Procurement Specificati		0	08/03/99	09/13/99						
2.4.1.3		Procure DM Filter		0	04/23/01 A	07/20/01 A						
2.4.1.4		Evaluate Filter Design		6	07/23/01 A	08/07/01						
2.4.1.5		Visual Inspection		2	08/08/01	08/09/01						
2.4.1.6		Vibration Test		1	08/10/01	08/10/01						
2.4.1.7		Visual Inspection		1	08/13/0	08/13/0						
2.4.1.8		Acoustic		3	08/14/01	08/16/01						
2.4.1.9		Visual Inspection		2	08/17/01	08/20/01						
2.4.2		Flight Model Filter		135	08/21/01	02/25/02						
2.4.2.1		Update Filter Desigr		10	08/21/0	09/03/0						
2.4.2.2		Procure Flight Filter(s)		60	09/04/01	11/26/01						
2.4.2.3		Assemble Flight Filter Assembly		20	11/27/01	12/24/01						
2.4.2.4		Evaluate Filter Design		45	12/25/01	02/25/02						
2.5		Grating Assembly		149	02/01/99	02/22/02						
2.5.1		Development Model (DM) Grating Assembly		73	02/01/99 A	11/08/01						
2.5.1.1		Define Grating optical requirements		0	02/01/99 A	11/05/99 A						
2.5.1.2		Design focussing mechanism		0	04/26/99 A	12/31/99 A						
2.5.1.3		Fabricate focussing mechanism		0	12/31/99	03/23/00						
2.5.1.4		Procure/fabricate Mass Sim Optic		0	12/04/00 A	12/15/00 A						
2.5.1.5		Procure Commercial Stepper Motors/Resolvers		0	04/10/00 A	09/13/00 A						
2.5.1.6		Assembly focussing mechanism		0	06/16/00 A	10/06/00 A						
2.5.1.7		Integrate mass sim		0	01/03/01	01/19/01						
2.5.1.8		Test and debug		0	01/22/01 A	02/09/01 A						
2.5.1.9		Static load testing		0	02/12/01 A	02/16/01 A						
2.5.1.10		Functional testing		21	02/26/01 A	08/28/01						
2.5.1.11		Fabricate test fixtur		0	04/23/01	04/27/01						
2.5.1.12		Vibration		3	08/29/01	08/31/01						
2.5.1.13		Functional Test		3	09/03/01	09/05/01						
2.5.1.14		Thermal Vacuum		20	09/06/01	10/03/01						
2.5.1.15		Functional Test		3	10/04/01	10/08/01						
2.5.1.16		Life Test		20	10/09/0	11/05/0						
2.5.1.17		Functional Test		3	11/06/01	11/08/01						
2.5.2		Flight Model Grating		149	03/24/00 A	02/22/02						
2.5.2.1		Update optical design		10	11/09/01	11/22/01						
2.5.2.2		Update focussing mechanism desic		10	09/03/0	09/14/0						
2.5.2.3		Procure flight grating		44	03/24/00 A	09/28/01						
2.5.2.4		Coat flight grating		20	10/01/01	10/26/01						
2.5.2.5		Characterize flight grating		20	10/29/01	11/23/01						

WBS Code		Description	Rem Dur	Early Start	Early Finish	2000	2001	2002	2003	2004	2005
2.5.2.1		Procure coated set-up gratings	44	05/19/00	09/28/00						
2.5.2.7		Optically test set-up gratings	10	10/01/01	10/12/01						
2.5.2.8		Procure/fabricate focusing mechanism	40	09/17/01	11/09/01						
2.5.2.9		Procure flight stepper motor/resolver	44	04/02/01 A	09/28/01						
2.5.2.10		Assemble focusing mechanism	40	10/15/00	12/07/00						
2.5.2.11		Integrate focusing mechanism - grating optics	15	12/10/01	12/28/01						
2.5.2.12		Spectrometer optical functional testing	40	12/31/01	02/22/02						
2.6		Mechanism Driver Electronics	238	05/31/01 A	06/27/02						
2.6.1		Hardware: Analog, Digital and Auxiliary CCA	238	05/31/01	06/27/00						
2.6.1.1		Brassboard Development	115	05/31/01 A	01/07/02						
2.6.1.1.1		Integration of BB CCAs to Power Converter Subsy	0	06/04/01 A	06/08/01 A						
2.6.1.1.2		Test and Debug	0	05/31/01 A	07/06/01 A						
2.6.1.1.3		Develop Draft EEE Parts Li:	0	05/31/01	06/20/01						
2.6.1.1.4		Layout/fabricate Brassboard PWB's	18	07/30/01 A	08/23/01						
2.6.1.1.5		Procure/receive brassboard components	40	08/09/01	10/03/01						
2.6.1.1.6		Assemble brassboard CCAs	10	10/04/01	10/17/01						
2.6.1.1.7		Test and debug CCA's	20	10/18/01	11/14/01						
2.6.1.1.8		Integrate embedded code, test and del	25	11/06/00	12/10/00						
2.6.1.1.9		Integrate and test with DM Pwr Converter Subsys	10	12/11/01	12/24/01						
2.6.1.1.10		Test and debug with DM mechanisms	10	12/25/01	01/07/02						
2.6.1.1.11		Deliver to MSSL for ICU integration and test	0		01/07/02						
2.6.1.1.12		Flight Development	238	05/31/01	06/27/00						
2.6.1.2.1		Flight parts list development	10	05/31/01 A	08/13/01						
2.6.1.2.2		Procurement plan development	10	06/11/01 A	08/13/01						
2.6.1.2.3		Flight parts procurement	20	08/14/01	09/10/01						
2.6.1.2.4		Flight parts receipt	90	09/04/00	01/07/00						
2.6.1.2.5		EEE parts screening	45	11/20/00	01/21/00						
2.6.1.2.6		Release flight PWB's	0	01/09/02							
2.6.1.2.7		Procure PWB's	10	01/08/02	01/21/02						
2.6.1.2.8		Receive and inspect PWB's	5	01/22/02	01/28/02						
2.6.1.2.9		Coupon testing	15	01/22/00	02/11/00						
2.6.1.2.10		Release flight CCA drawing	0	01/08/02							
2.6.1.2.11		Generate CCA assembly drawings	10	01/08/02	01/21/02						
2.6.1.2.12		Kit CCA's	10	01/22/02	02/04/02						
2.6.1.2.13		Kit inspections	5	02/05/02	02/11/02						
2.6.1.2.14		Assemble CCA's	20	02/12/00	03/11/00						
2.6.1.2.15		Trim test	20	03/12/02	04/08/02						
2.6.1.2.16		Rework (A/R) and inspection	5	04/09/02	04/15/02						
2.6.1.2.17		Integrate flight embedded code	5	05/03/02	05/09/02						
2.6.1.2.18		Functional tes	15	05/10/00	05/30/00						
2.6.1.2.19		Integrate housing and power subsystem	5	05/31/02	06/06/02						
2.6.1.2.20		Functional test	15	06/07/02	06/27/02						
2.6.2		Embedded Control Code	223	06/11/01 A	06/06/02						

WBS Code		Description	Rem Dur	Early Start	Early Finish	2000	2001	2002	2003	2004	2005
2.6.2.1		Develop and deliver MDC simulator to MS:	5	10/01/00	10/05/00						
2.6.2.2		Validate commanding/telemetry with ICU (MSSL)	10	10/08/01	10/19/01						
2.6.2.3		Update embedded code	70	06/11/01 A	11/05/01						
2.6.2.4		Integrate into brassboard hardware	0	11/06/01							
2.6.2.5		Test, Debug and Validate	128	11/06/00	05/02/02						
2.6.2.6		Integrate with Flight CCA's	0	05/03/02							
2.6.2.7		Test, Debug and Validate	25	05/03/02	06/06/02						
3		Ground Support Equipment and Proto Models	106	09/01/99 A	12/25/01						
3.1		Electrical Proto Mode	0	11/01/99	07/06/01						
3.1.1		Mechanism Driver Electronics Proto Design	0	11/01/99 A	12/31/99 A						
3.1.2		Procure Components	0	12/31/99 A	02/10/00 A						
3.1.3		Fabricate PCB's	0	04/10/00	05/05/00						
3.1.4		Assembly Proto Model	0	02/11/00 A	03/09/00 A						
3.1.5		Test and Debug	0	05/26/00 A	07/06/01 A						
3.1.6		Develop CDR Data Package for MH	0	05/21/01	07/06/01						
3.2		Mechanical/Thermal Prot Model	0	12/08/00 A	02/21/01 A						
3.2.1		Fabricate Grating Mass model	0	12/08/00 A	02/16/01 A						
3.2.2		Deliver to MSSL	0	02/21/01 A							
3.2.3		Fabricate Mirror mass model	0	12/08/00	02/16/01						
3.2.4		Deliver to MSSL	0	02/21/01 A							
3.2.5		Fabricate Slit/Slot/Shutter mass model	0	12/08/00 A	02/16/01 A						
3.2.6		Deliver to MSSL	0	02/21/01 A							
3.3		Electrical Ground Support Equipme	70	02/01/00	12/25/00						
3.3.1		Complete Mechanism Controller	0	07/06/01 A							
3.3.3		Procure Assemblies (A/R)	10	09/19/01	10/02/01						
3.3.2		Define EGSE Requirements	0	02/01/00 A	02/01/00 A						
3.3.4		Assemble EGSE	40	10/03/00	11/27/00						
3.3.5		Test and Debug	20	11/26/01	12/25/01						
3.4		Mechanical Ground Support Equipment	105	02/01/00 A	12/24/01						
3.4.1		Define MGSE Requirements	0	02/01/00 A	04/24/00 A						
3.4.2		Fabricate MGSE	45	03/19/01	10/01/00						
3.4.3		Test MGSE	60	10/02/01	12/24/01						
3.5		Mock-ups and Simulators	0	09/01/99 A	01/12/01 A						
3.5.1		Front Filter Assembly	0	09/01/99 A	01/12/01 A						
3.5.1.1		Support UB in design of FFA Clamshell	0	09/01/99 A	03/28/00 A						
3.5.1.2		Support UB in fabrication of Clamsh	0	03/28/00	01/12/01						
4		Systems Engineering and Integration	1089	02/02/99 A	09/30/05						
4.1		Systems Engineering	1089	02/02/99 A	09/30/05						
4.1.1		Systems Engineering Support	1089	02/02/99 A	09/30/05						
4.1.2		MSSL systems engineering support	613	06/01/99	12/04/00						
4.1.3		U. of B. systems engineering support	613	06/02/99 A	12/04/03						
4.2		Instrument Components Testing and Verification	108	04/04/02 A	09/02/02						
4.2.1		Environmental Acceptance Testing	105	04/04/02 A	08/28/02						



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Naval Research Laboratory EIS CDR Baseline Program Schedule



Appendix B. ASTM-E 1559 Outgassing/Deposition Kinetics Test Results



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Outgassing Measurements on Honeycomb Composite Panel

Prepared for:

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July 12, 2001

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ASTM E 1559

Outgassing/Deposition Kinetics Test

Test Method

The material sample is placed in a temperature-controlled effusion cell in a vacuum chamber. Outgassing flux leaving the effusion cell orifice impinges on four QCMs which are controlled at selected temperatures. One of the QCMs is at 80 K to collect essentially all the impinging species. The total mass loss (TML) and outgassing rate from the sample are determined as functions of time from the mass deposited on this QCM and the sample-to-QCM view factor. The percent of outgassing species which are condensable on higher temperature surfaces is referred to as Volatile Condensable Material (VCM) and is measured as a function of time from the mass collected on the warmer QCMs, which are temperature-controlled appropriately. The QCMs and effusion cell are surrounded by liquid nitrogen shrouds to ensure that the molecular flux impinging on the QCMs is due only to the sample in the effusion cell.

After the isothermal outgassing test, a QCM thermogravimetric analysis (QTGA) is performed on the condensed outgassed species. The QCMs are individually heated at a controlled rate from their base temperatures to 398 K in order to volatilize the collected species, while the mass remaining on the QCMs is measured as a function of time and temperature. In general, the collected species have different evaporation characteristics and hence will leave the QCM surface at different temperatures. Therefore, QTGA data are characterized by temperature regimes in which the deposit mass remaining on the QCM decreases due to evaporation of a particular species, separated by temperature regimes in which no species evaporate. The number of temperature regimes in which the QCM deposit mass decreases indicates the number of major species present in the outgassing flux. The relative amount of a given species in the outgassing flux can be estimated from the ratio of the mass loss associated with the evaporation of that species to the total deposit mass on the QCM. QTGA also provides an effective means to clean the QCM surfaces before subsequent outgassing tests.

The species outgassed from the sample during the isothermal test, and evaporating from the QCM during the QTGA also are monitored using a mass spectrometer. While the QCMs provide quantitative outgassing and deposition data, the mass spectrometer records the intensities of mass peaks which aid in the identification of the outgassed species.

Test Parameters

Outgassing testing was performed using the following chamber and test parameters.

- Chamber pressure was 10^{-10} to 10^{-9} torr
- View factor from a QCM to the sample was 415.02 cm²
- Sensitivity of each of the four QCMs was 4.43×10^{-9} g/cm²/Hz

References

- ASTM E 1559, "Standard Test Method for Contamination Outgassing Characteristics of Spacecraft Materials."
- J.W. Garrett, A.P.M. Glassford, and J. M. Steakley, "ASTM E1559 Method for Measuring Material Outgassing/Deposition Kinetics", Journal of the IEST, pp. 19-28, Jan/Feb 1995
- A.P.M. Glassford and J.W. Garrett, "Characterization of Contamination Generation Characteristics of Satellite Materials", Final Report WRDC-TR-89-4114, Jun 82 - Aug 89

ASTM E 1559
Outgassing/Deposition Kinetics Test

Test Material:

Honeycomb Composite Panel

Material Description:

The honeycomb composite panel consisted of a metal honeycomb core with two composite facesheets. The facesheets were attached to the honeycomb core with adhesive.

Material Packaging:

The test material was received in a clear plastic bag.

Material Supplier:

The test material was supplied by Clarence Korendyke of the Naval Research Laboratory.

Sample Description:

The test sample consisted of one honeycomb composite panel that was nominally 1.2" x 1.1" x 0.45". The sample area noted below includes one face only of the honeycomb sandwich.

Sample Preconditioning:

No sample preconditioning.

Sample Area: 8.6 cm²

Sample Mass: 2.32395 g

Sample Temperature: 80/40 °C (QCMs = 160 K were heated after 80°C

Test Duration: 72/67 hr portion of testing to remove deposits.)

QCM Temperatures: 80 K 213 K 253 K 293 K

Isothermal Data File: JUL0301G

QTGA Data File: JUL0901R

Isothermal Test - QCM Data:

QCM data at the end of 72 hours of the outgassing test at 80°C are summarized in Table 1.

Table 1

	$(\mu\text{g}/\text{cm}^2)$		(%)		(% of TML)
80 K TML =	417.3	=	0.1552	=	100.0
213 K VCM =	7.9	=	0.0029	=	1.9
253 K VCM =	3.7	=	0.0014	=	0.9
293 K VCM =	1.2	=	0.0004	=	0.3

QCM data at the end of the 139 hour test (first 72 hours at 80°C and final 67 hours at 40°C) are summarized in Table 2.

Table 2

	$(\mu\text{g}/\text{cm}^2)$		(%)		(% of TML)
80 K TML =	418.1	=	0.1554	=	100.0
213 K VCM =	7.9	=	0.0029	=	1.9
253 K VCM =	3.7	=	0.0014	=	0.9
293 K VCM =	1.2	=	0.0004	=	0.3

Total outgassing rate data for the sample were calculated by differentiating the total mass loss data obtained from the 80 K QCM. The figures showing these total outgassing rate data as a function of test time are attached. These outgassing rates include all species condensable at 80 K in the vacuum chamber. These species would include high volatility species such as solvents and water but not certain gases such as nitrogen, oxygen, argon, et cetera.

The outgassing rates for species condensable on the warmer QCMs can be calculated from curve fits to data acquired at the end of the outgassing test. The outgassing rates for species condensable on the warmer QCMs can be compared with the total outgassing rates from the 80 K QCM to determine the levels of outgassing due to the less volatile (higher molecular weight) species. These data are presented in Tables 3 and 4.

Table 3

Outgassing Rates of Species Condensable on the Different QCMs				
	<u>80 K QCM</u>	<u>213 K QCM</u>	<u>253 K QCM</u>	<u>293 K QCM</u>
Data at 72 hours:				
(end of 80°C test)	39.4 pg/cm ² /s	9.5 pg/cm ² /s	4.3 pg/cm ² /s	< 0.1 pg/cm ² /s
	146.4 pg/g _s /s	35.5 pg/g _s /s	15.8 pg/g _s /s	< 0.4 pg/g _s /s
	100 %	24.2 %	10.8 %	< 0.3 %

Table 4

Outgassing Rates of Species Condensable on the Different QCMs				
	<u>80 K QCM</u>	<u>213 K QCM</u>	<u>253 K QCM</u>	<u>293 K QCM</u>
Data at 139 hours:				
(end of 40°C test)	1.7 pg/cm ² /s	< 0.1 pg/cm ² /s	< 0.1 pg/cm ² /s	< 0.1 pg/cm ² /s
	6.3 pg/g _s /s	< 0.4 pg/g _s /s	< 0.4 pg/g _s /s	< 0.4 pg/g _s /s
	100 %	< 6 %	< 6 %	< 6 %

QCM Thermogravimetric Analysis - QCM Data:

The QTGA test data can be used to determine the relative amounts of the species outgassed. As the temperature of the 80 K QCM is increased during QTGA, the collected species will evaporate from the QCM in order of their relative volatilities. The attached QTGA data are plotted as evaporation rate from the QCM as a function of QCM temperature.

The relative amounts of each of the distinct evaporation regions are indicated in the QTGA figures. The evaporation characteristics of the first species are consistent with water and high volatility solvents and it makes up about 98 % of the condensable outgassing flux from the sample during the isothermal outgassing test. The other evaporation groups are responsible for the volatile condensable material on the warmer QCMs.

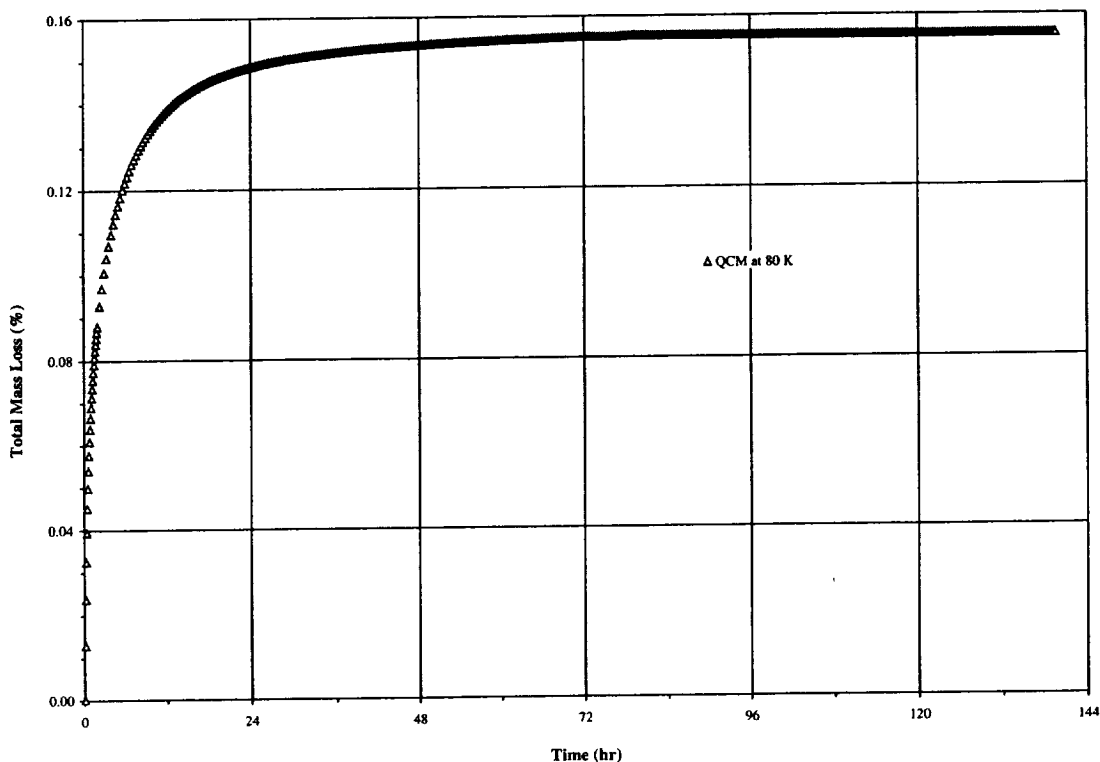
Mass Spectrometer Data:

Data from the in situ mass spectrometer are sometimes used to help identify the outgassed species. Identification of outgassed species is not within the normal scope of work for this testing and is not ordinarily pursued because of the analysis time required. Mass spectrometer data was acquired throughout the isothermal outgassing test and the subsequent QCM thermogravimetric analysis. These data are archived if further analysis is necessary.

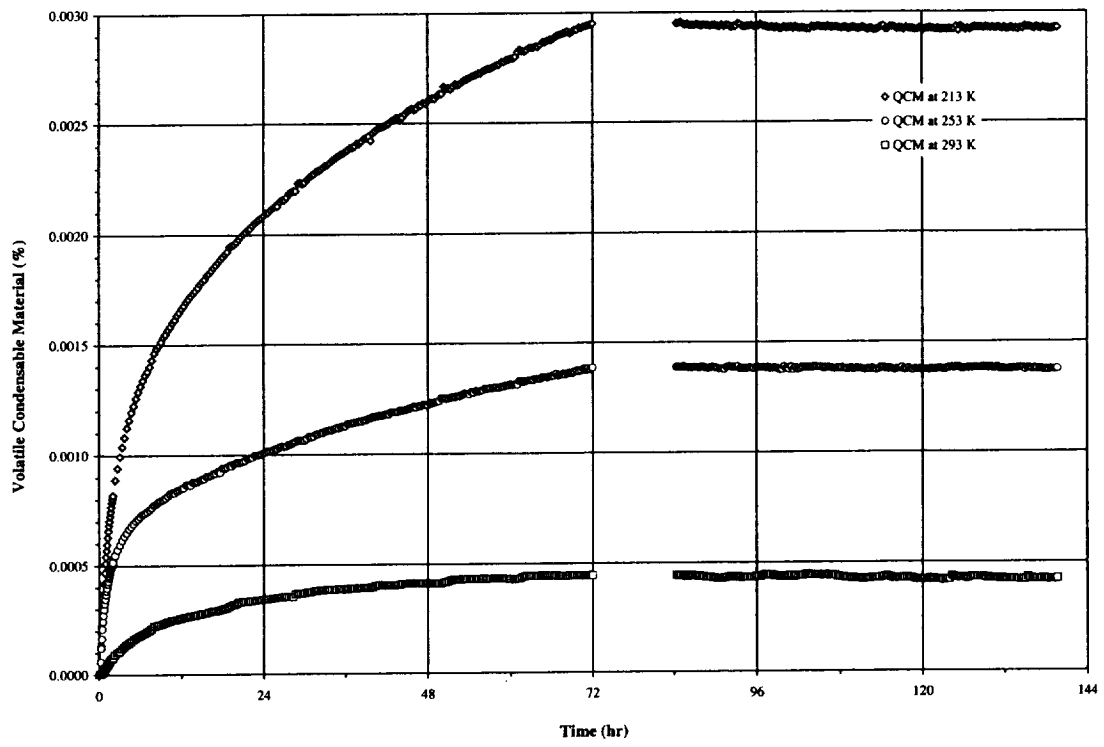
Attachments:

- Figs. 1(a-b). Total Mass Loss from the Sample as a Function of Test Time.
(Species Condensable on the 80 K QCM)
- Figs. 2(a-b). Volatile Condensable Material from the Sample on the Warmer QCMs
as a Function of Test Time.
- Figs. 3(a-b). Total Outgassing Rate for the Sample as a Function of Test Time.
(Species Condensable on the 80 K QCM)
- Figs. 4(a-b). QTGA Data: Evaporation Rate from the 80 K QCM of the Collected
Outgassed Material as a Function of QCM Temperature.

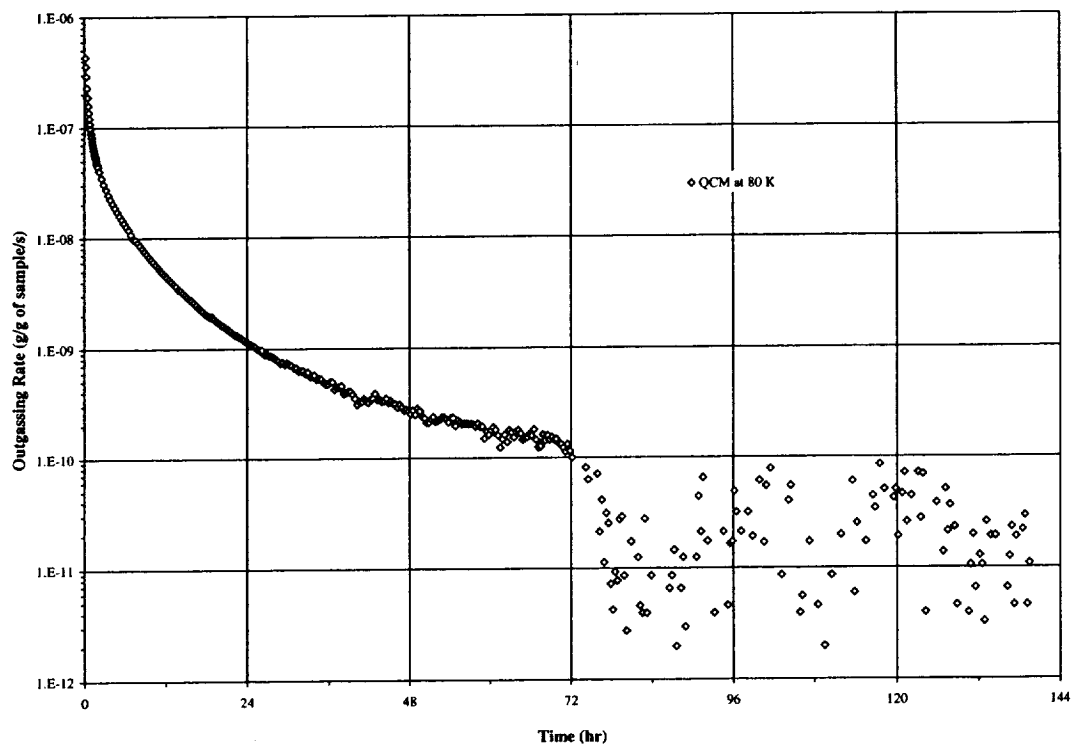
JUL0301G: Honeycomb Composite Panel.
(80°C for 72 hours then 40°C for the remainder of the 139 hour test)



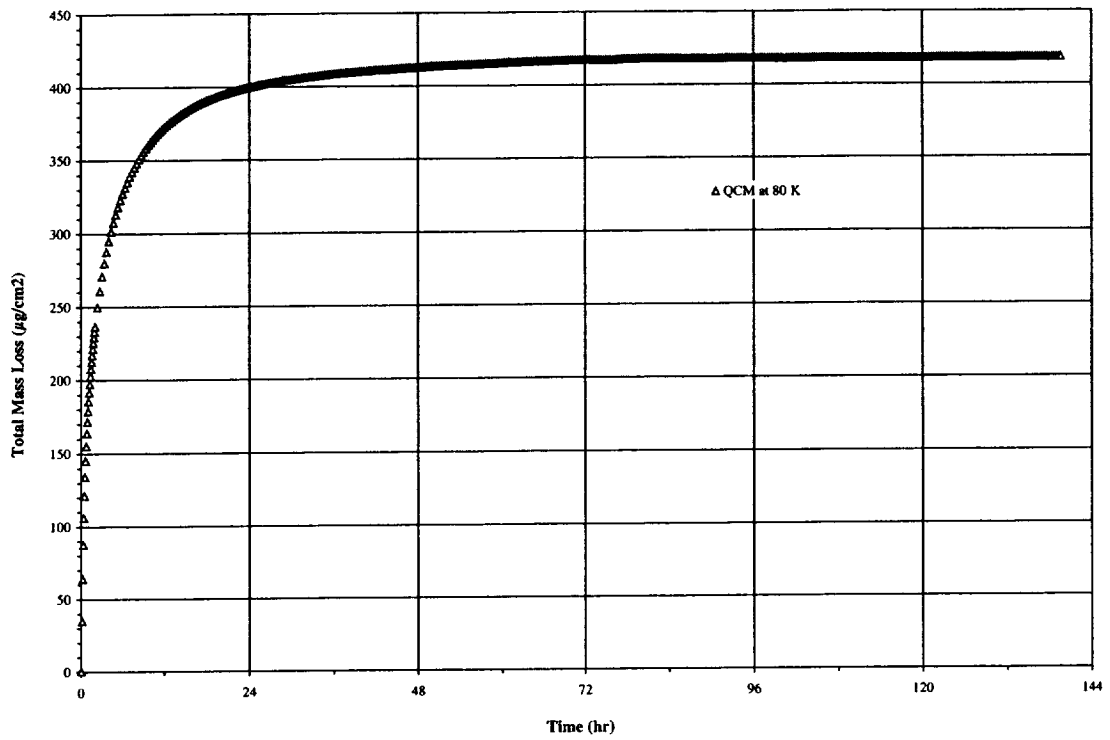
JUL0301G: Honeycomb Composite Panel.
(80°C for 72 hours then 40°C for the remainder of the 139 hour test)



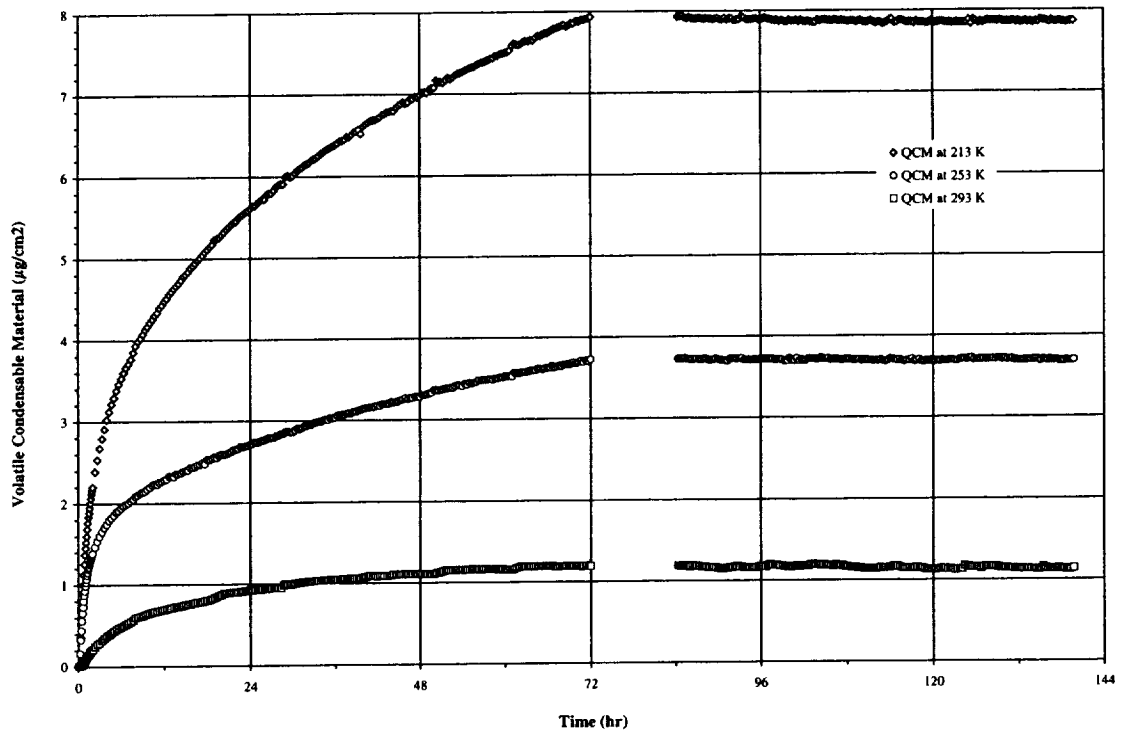
JUL0301G: Honeycomb Composite Panel.
(80°C for 72 hours then 40°C for the remainder of the 139 hour test)



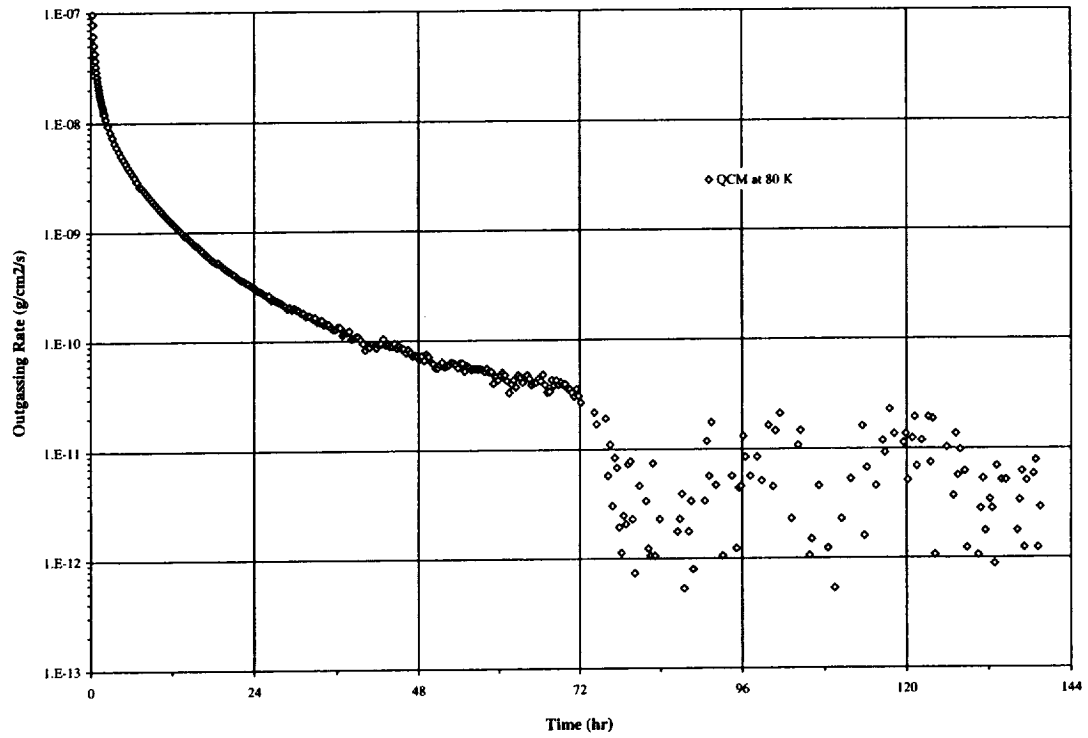
JUL0301G: Honeycomb Composite Panel.
(80°C for 72 hours then 40°C for the remainder of the 139 hour test)



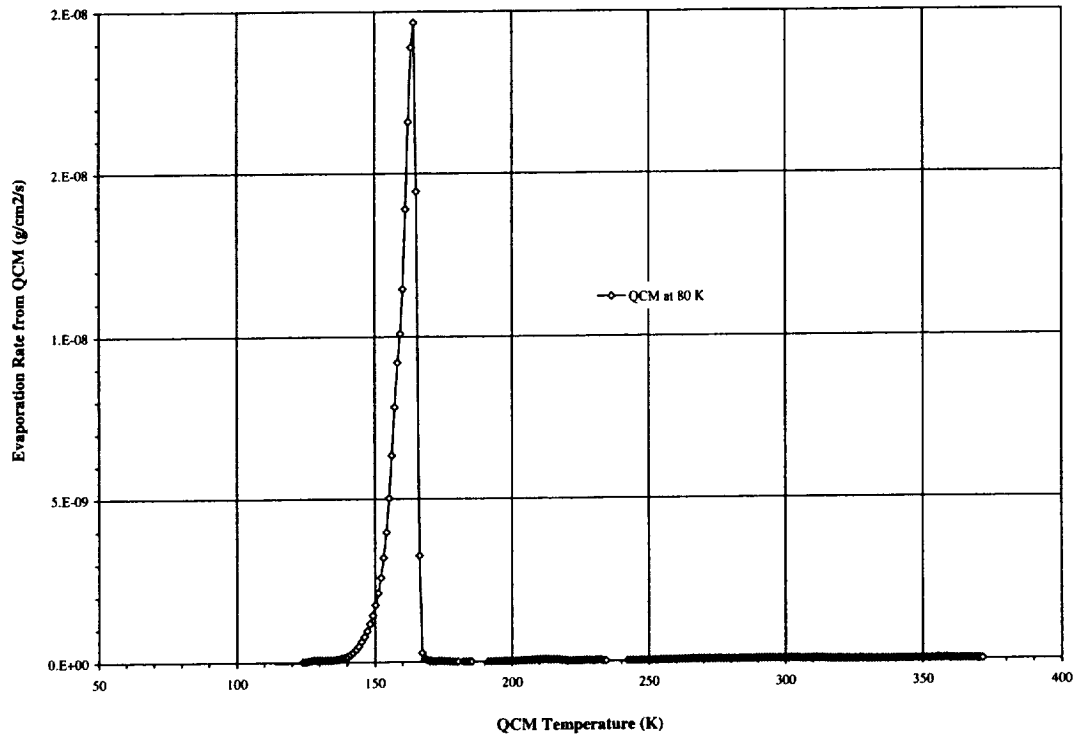
JUL0301G: Honeycomb Composite Panel.
(80°C for 72 hours then 40°C for the remainder of the 139 hour test)



JUL0301G: Honeycomb Composite Panel.
(80°C for 72 hours then 40°C for the remainder of the 139 hour test)



JUL0901R: QTGA after Honeycomb Composite Panel.
(80°C for 72 hours then 40°C for the remainder of the 139 hour test)



JUL0901R: QTGA after Honeycomb Composite.
(80°C for 72 hours then 40°C for the remainder of the 139 hour test)

